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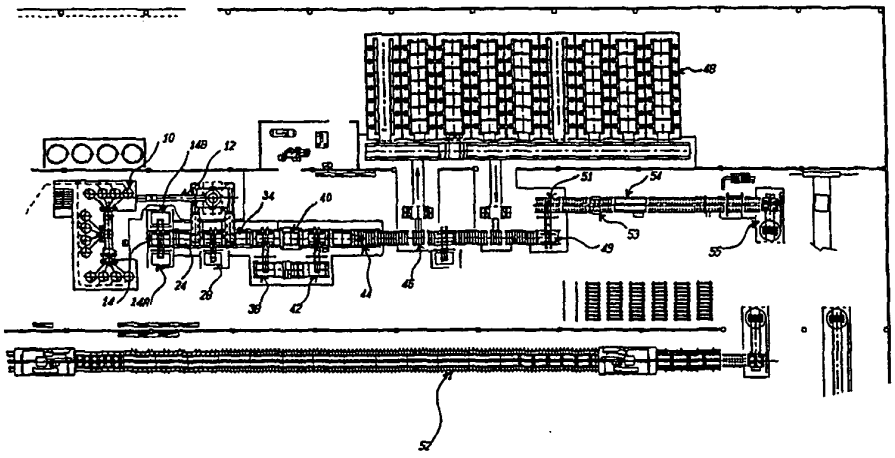

(57) Abstract

During the manufacture of slabs of ceramic material from a mixture formed by a grannulated material and by an inorganic binding phase, the starting mixture is spread on a support constituted by a mechanically resistant fabric or felt covered with a layer or sheet of release material permeable to water vapour such as paper, and the layer of mixture is covered with a protective sheet of release material, preferably rubber, after which forming is carried out by the application of a compacting pressure under vacuum combined with the simultaneous application of a vibratory motion; the resulting raw slab is released from the rubber sheet, transferred by pincer means to a support or metal grid used for the drying and firing steps, and is then sent to a drying oven after which, when the felt sheet has been removed, the visible surface is covered with a layer of refractory material and the raw slab is turned over and sent to the firing kiln where the permeable paper is removed by burning.

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"Method and apparatus for the manufacture of slabs of ceramic material"

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The present invention relates to the manufacture of slabs of ceramic material and, more specifically, to an improvement in apparatus for the manufacture of such products.

The following description will relate specifically to the manufacture of slabs of ceramic material of the type known commercially by the name of "Lapitech", that is, technological porcelain or porcelainised stoneware, upon the understanding that this reference is not intended to be limiting but is purely an example of the preferred embodiment of the invention.

European patent 378,275 describes a slab of ceramic material and a method for its manufacture which provides for the preparation of a ceramic mixture constituted by granulated material and by an inorganic binding phase having particular characteristics of composition; the granulated material also has specific particle-size parameters.

The mixture is formed into slabs by being spread on a forming support and a pressure, combined with a simultaneous vibratory motion, is applied to the mixture thus spread, which is kept under vacuum.

After the forming stage, the raw slab is subjected to a first, drying step at a temperature below that at which ceramics are fired but nevertheless greater than 100°C and to a second, firing step in which the dried slab is brought to a temperature of the order of 1000-1300°C.

In the practical implementation of the above-mentioned method and for the reasons which will be explained below, before the metered quantity of mixture is deposited on the forming support, it is protected (for example, from possible soiling and from the formation of deposits) by means of a sheet or strip of paper.

The layer of mixture deposited is then covered by a layer or sheet of paper permeable to water vapour and the whole thing is then transferred to the step for pressing under vacuum and simultaneous application of vibratory motion.

The raw slab thus formed is picked up by devices with suction cups and is transferred, whilst being kept in the same position and the same orientation, onto a support surface, preferably in the form of a metal mesh, after which the sheet of permeable paper is removed.

The raw slab is then transferred to the drying step after which a layer of refractory material (which is known in the art as a "refractory slip"), the composition of which generally consists of magnesium carbonate and a plastic clay which are mixed with water, is applied to its upper surface.

After the application of the protective refractory layer, the raw slab is turned over in order to be introduced into the firing kiln where the protective paper, which at this stage constitutes the upper covering of the dried slab, is removed (by burning) whilst the lower surface of the slab which is in contact with the support on which the slab is transported or rests in the kiln (according to the type of kiln) is protected by the aforementioned layer of refractory material (the slip).

This layer may be removed by conventional techniques upon completion of the firing step, after which the slab goes on to conventional finishing operations (sizing, smoothing, polishing) if desired.

It is clear from the short description given above that the processing requires many precautions by the operators to prevent damage particularly to the raw slabs before both drying and firing, with problems and disadvantages which are not due to the main characteristics of the process for the manufacture of these slabs but which have a considerable effect on industrial production costs.

The main object of the present invention is to prevent these problems and disadvantages by improvements to be introduced in the apparatus and in the method of manufacture of the slabs defined above, without detriment to the properties, quality, or appearance of the resulting slabs.

This object is achieved by the present invention which provides for a method for the manufacture of slabs of ceramic material of the type identified above which is characterized in that the starting mixture is deposited on the forming support after a layer of mechanically resistant fabric, particularly felt, has been arranged on this support, a layer of release material, permeable to water vapour preferably paper, being placed on the felt and the layer of mixture disposed on the support thus prepared being covered with a sheet of a release material, such as rubber or another substantially elastomeric material, after which the step of pressing under vacuum with the simultaneous application of a vibratory motion of predetermined frequency and duration is carried out and, before the drying step and the subsequent firing step, the aforementioned rubber sheet is removed and the raw slab is transferred to the subsequent drying step by the gripping of the front portion (with reference to the direction of movement of the support along the production line) of the felt carrying the raw slab by pincer means so as to transfer the assembly onto a grid-like support to be introduced into the drying oven and, after the layer of refractory slip has been applied to the raw slab coming from the drying stage and the slab has been turned over, it is then introduced into the firing kiln after the aforementioned layer of fabric or felt has been removed so that the raw slab bears on the grid-like support with the interposition of the aforementioned refractory slip whilst the sheet or layer of permeable paper which, at this point, covers the upper surface of the slab, is removed by burning.

In turn, the apparatus according to the present invention, which is of the type comprising means for preparing the starting mixture of granulated material and binding phase, means for supplying and spreading a metered quantity of the mixture onto a support movable along the production line, means for the pressing under vacuum of the metered quantity of mixture spread on the support and the simultaneous application of a vibratory motion thereto, a drying zone, means situated downstream of the drying zone for applying a layer of refractory material for protecting the raw slab, and a zone for the firing of the raw slabs supported on the side covered by the layer of refractory material, is characterized in that it comprises means for supplying a layer of mechanically resistant fabric, preferably a felt, and placing it in position on the movable support upstream of the position in which the starting mixture is supplied and spread, means for supplying a layer of release material permeable to water vapour , preferably paper,

and placing it in position on the layer of felt, means for supplying a layer or sheet or rubber and placing it in position downstream of the means for supplying and spreading the mixture and upstream of the means for pressing under vacuum, means for removing the layer or sheet of rubber downstream of the means for pressing under vacuum, pincer means for gripping the front portion of the layer of fabric or felt in order to transfer the felt, on top of which the layer of permeable paper and the slab of raw mixture is carried, onto a grid-like support movable in a controlled manner along the production line for introduction into the drying zone, means for picking up and removing the layer of felt prior to introduction into the firing zone when the raw slab, which has come out of the drying zone, is turned over after the refractory layer of slip has been applied, the contact between the slab and the means supporting it in the kiln being constituted solely by the layer of refractory material, whilst the sheet or layer of permeable paper covers the upper surface of the raw slab.

In the following description of a preferred embodiment of the present invention, given with reference to the appended drawings, reference is made to apparatus and devices which are known per se in the art and do not therefore require more detailed description.

In the appended drawings:

Figure 1 is a general plan view of the apparatus according to the invention,

Figures 2A and 2B are schematic side elevational views of a portion of the apparatus of the present invention,

Figures 3A and 3B are plan views of the portion of the apparatus of Figures 2A and 2B,

Figures 4, 5, 6, 7, 8, 9, and 10 are partial views showing in section the raw slabs in the successive stages of their formation and movement through the various stations of the apparatus, the sections relating to the positions indicated S4, S5, S6, S7, S8, S9, and S10 in Figures 2A and 2B, and

Figure 11 shows the detail of the apparatus identified by the oval in Figure 2B.

It should be pointed out that, for clarity of illustration, both Figure 2 and Figure 3 have been divided into two halves so that Figures 2B and 3B should be understood as continuations of Figures 2A and 3A, respectively, showing an integral set of apparatus.

Moreover, Figures 4 to 10 show a support structure comprising a framework 18 which supports for movement a conveyor belt 20 which may differ in the various portions of the apparatus. For example, in the drying and firing zones, the conveyor is replaced by a support surface made of heat-resistant material.

With reference first of all to Figure 1, the section of the apparatus for preparing the starting mixture is indicated 10, the mixture passing through the duct 12 and being transferred to the mixture-supply and spreading stations.

The production line starts with a station 14 which provides for the loading of a felt or cloth 16 in the portion 14A and provides for a sheet or layer of paper 22 permeable to water vapour to be placed on the felt 16 in the portion 14B; the conveyor belt 20 then enters the station 24 in which a mixture-supply and

spreading mechanism spreads on top of the sheet of permeable paper 22 a layer 26 of mixture of predetermined thickness, taken from the supply duct or channel 12.

The embodiment shown, provides for a reinforcing mesh to be inserted and incorporated in the thickness of the final layer of mixture and the station 24 is therefore followed by a station 28 for loading a mesh 30 of a material compatible with the final slab and placing it in position on top of the layer of mixture 26. By compatibility is meant, in particular, that the shrinkage of the material constituting the reinforcing mesh should be substantially of the same order of magnitude as that of the mixture when it is subjected to the drying and firing steps.

A second layer 32 of the same mixture is placed on top of the reinforcing mesh 30, forming the layer 26. in the station 34.

Before being subjected to the action of the vacuum forming and compaction press and the simultaneous application of a vibratory motion of predetermined frequency and duration, the upper surface of the mixture and thus of the layer 32, is covered and protected by a sheet of elastomeric release material such as, for example rubber, this sheet, identified by the reference numeral 36, being applied in the station 38.

As can be seen from Figure 8, the rubber sheet 36 has dimensions such that its periphery overlaps the peripheries of the permeable paper sheet 22 and of the felt 16 which also project, so that the mixture which, in this case, is constituted by two layers 26 and 32 with the reinforcing mesh 30 interposed between them, is completely enclosed by a protective envelope which, however, is porous on the lower side (by virtue of the presence of both the felt and the permeable paper) allowing moisture also to come out of the lower side during the subsequent drying step.

The mixture is then transferred to the pressing station 40 where it is subjected, under a pre-established vacuum, to a predetermined pressure and to the simultaneous effect of a vibratory motion, forming a raw slab which does not, however, yet have sufficient mechanical solidity to be handled without special measures.

At the output of the pressing station 40, first of all, the rubber sheet is removed (station 42) and is returned to the application station 38 after suitable cleaning of residues of mixture. The raw slab, which is now in the condition of Figure 10, is advanced to the station 44 where it is transferred onto a different conveyor support, preferably constituted by a metal grid.

For this purpose, and to avoid the above-mentioned handling difficulties, in the station 44 there are pincer means which can grip the projecting front edge (in the direction of advance of the conveyor belt) of the felt 16 and of the permeable paper 22, so that the raw slab is slid forwards, together with the felt and the permeable paper, until it engages the new conveyor support constituted, in fact, by a metal grid.

The above-mentioned pincer means are shown in greater detail in Figure 11.

With reference to this drawing and to Figures 2B and 3B, it can be stated that these means are constituted substantially by a rectangular frame 70 which is formed by a series of side members and cross members arranged side by side and parallel to one another (see Figure 3B) and which is movable forwards and

backwards relative to the fixed load-bearing structure on which it is mounted between a position for depositing a slab on the grid and a position for gripping the felt where the slab is lying; Figure 3B shows in broken outline the shape of the portion of the frame arranged for gripping a slab arriving in this latter position.

In this embodiment, the frame is moved by an electric motor 71 acting on a shaft 72 at the ends of which there are respective pinions (not shown in the drawings) coupled with corresponding racks (also not shown graphically) mounted on the fixed load-bearing structure.

The gripping action of the pincer means is ensured by a lower lip 75 and an upper lip 76, of which the former is fixed to the frame 70 and the latter is movable relative thereto since it is fitted on the translating element 77 of an articulated- quadrilateral kinematic mechanism of which two rocker arms 78 articulated to the frame 70 also form part; in particular, the movement of the upper lip 76 is brought about by a series of hydraulic cylinders 80 mounted on the frame and acting on the translating element 77.

After the pincer means have released the felt and the permeable paper, the raw slab thus reaches the station 46 where it is advanced, together with the grid-like support on which it is deposited, towards a drying oven 48 of conventional type well-known per se, in which it is subjected to the effect of heat, preferably in the form of a forced circulation of hot air, the time spent in the oven being such as to achieve a first mechanical solidification of the mixture which forms the raw slab so that it can withstand gentle mechanical handling.

At the output of the drying oven, the slab, still on the grid-like support, is sent to the station 49 in which it is lifted up by a suction-cup system and transferred to a starting station 51 of the next portion of the conveyor 20; after this lifting, the grid-like support and the felt disposed thereon can then be taken from the station 49 for re-use in the production cycle as described above.

From the station 51, the slab then reaches the station 53 where a thin layer of refractory material (the aforementioned slip) is applied to it and is then dried in the next station 54; after this, the slab is turned over in the station 55; that is to say, as a result of this turning over, the layer of slip, solidified by drying, is disposed underneath the slab and in contact with the conveyor which moves it forwards.

At this point, it remains only to introduce the raw and dried slab resting on its face which is covered with and protected by the refractory slip, into the firing kiln 52, which is preferably of the tunnel type well-known per se, in which the firing of the mixture and its transformation into ceramic material is also combined with burning of the permeable paper which covers the upper surface of the raw slab.

After firing, the slab may be transferred to normal finishing operations such as smoothing, polishing, etc.

It is clear form the foregoing description that, with the present invention, the problems and disadvantages connected with pre-existing production technology are substantially eliminated in an industrially advantageous manner.

Although this should not be understood in any limiting sense, it can reasonably be considered that the advantages and results achieved by the present invention are due mainly to the use of the primary

supporting felt for the deposition of the starting mixture and to its coupling with the paper permeable to water vapour.

In fact, it thus becomes possible to achieve, on the one hand, a firm support for the deposition and spreading of the starting mixture and, on the other hand, a capability to transfer the raw slab to the drying stage without handling (with suction cups and the like) which might irreparably damage the raw slab just formed and compacted, as well as, in particular, changing of the support of the raw slab (for example, from a continuous conveyor belt to a metal mesh) simply by sliding of the formed and compacted raw slab by the gripping of the projecting edge of the felt by simple pincer means.

It is appropriate to point out that the results set out above are achieved without any change in the level of quality of the production cycle since the felt constitutes a layer which is permeable to water vapour, ensuring uniform drying on the two faces of the slab without warping or cracking.

Of course the felt or fabric must be mechanically resistant and particularly resisting to tensile stress.

Moreover, components such as the rubber sheets, can be re-used as they are (after merely being cleaned of debris and residues of mixture) so that industrial production costs are also controlled and, in particular, limited, whilst the number of slabs to be rejected owing to damage resulting from handling before the firing step is drastically reduced.

Finally, it should be understood that conceptually and mechanically equivalent modifications and variations are possible and foreseeable within the scope of the present invention.

For example, and in the first place, the two stations 24 and 34 may be reduced to a single station for the deposition and spreading of the mixture when the slab does not have to contain a reinforcing mesh 30.

Moreover, the present invention may be applied in a similar manner with suitable adjustments to processes and apparatus in which slabs are formed from mixtures which are subsequently subjected to drying and setting steps in which, up to now, the mixture generally had to be incorporated between two paper sheets for the pressing and subsequent operations, since it enables the raw slab to be handled without the hitherto unsolved problem of susceptibility to damage.

CLAIMS

1. A method of manufacturing sheets of ceramic material of the type identified above, characterized in that the starting mixture is deposited on the forming support after a layer of mechanically resistant fabric has been arranged on this support, a layer of release material permeable to water vapour being placed on the felt, and the layer of mixture deposited on the support thus prepared being covered with a protective sheet of material having substantially releasing effect, after which the step of pressing under vacuum with simultaneous application of a vibratory motion of predetermined frequency and duration is carried out and, before the drying step and the subsequent firing step, the aforementioned releasing material sheet is removed and the raw slab is transferred to the subsequent drying step by the gripping of the front portion (with reference to the direction of movement of the support along the production line) of the fabric carrying the raw slab by pincer means so as to transfer the assembly onto a rigid and planar grid-like support to be introduced into the drying oven and a layer of refractory material is applied to the raw slab after the removal thereof from the layer of fabric on which the dried raw slab is placed, and the slab is then turned over and introduced into the firing kiln on rollers so that it bears on the rollers of the kiln with the interposition of the aforementioned layer of refractory material, whilst the sheet or layer of permeable release material, which at this point covers the upper surface of the raw slab, is removed by burning.

2. A method of manufacturing slabs of ceramic material according to claim 1, characterized in that the mechanically resistant fabric is a felt.

3. A method of manufacturing slabs of ceramic material according to claim 1, characterized in that said layer of release material permeable to water vapour is paper.

4. A method of manufacturing slabs of ceramic material according to claim 1, characterized in that said protective sheet is of rubber or like substantially elastomeric material.

5. A method of manufacturing slabs of ceramic material according to any one of claims 1 and 2, characterized in that a reinforcing mesh is incorporated in the layer of mixture deposited on the forming support before the layer is covered with said protective sheet of material having release effect.

6. Apparatus for manufacturing slabs of ceramic material according to the method of the preceding claims, of the type comprising means for preparing the starting mixture of granulated material and binding phase, means for supplying and spreading a metered quantity of the mixture onto a support movable along the production line, means for the pressing under vacuum of the metered quantity of the mixture spread on the support and the simultaneous application of a vibratory motion thereto, a drying zone, means situated downstream of the drying zone for applying a layer of refractory material for protecting the raw slab, and a zone for the firing of the raw slabs supported on the side covered with the refractory material, characterized in that it comprises means for supplying a layer of mechanically resistant fabric and placing it in position on the movable support upstream of the position in which the starting mixture is supplied and spread, means for supplying a layer of release material permeable to water vapour and placing it in position on the said layer of fabric, means for supplying a protective layer

or sheet of release material and placing it in position downstream of the means for supplying and spreading the mixture and upstream of the means for pressing under vacuum, means for removing the said protective layer or sheet downstream of the means for pressing under vacuum, pincer means for gripping the front portion of the said layer of fabric in order to transfer the fabric, on top of which the said layer of permeable release material and the raw slab of mixture is carried, onto a rigid and planar, grid-like support movable in controlled manner along the production line for introduction into the drying zone, means for picking up and removing the said layer of fabric from the slab at the output from the drying zone, the slab being turned over after the application of the layer of refractory slip and prior to introduction into the firing zone and resting on its face which is protected by the layer of refractory material whilst the sheet or layer of permeable release material now covers the upper surface of the raw slab.

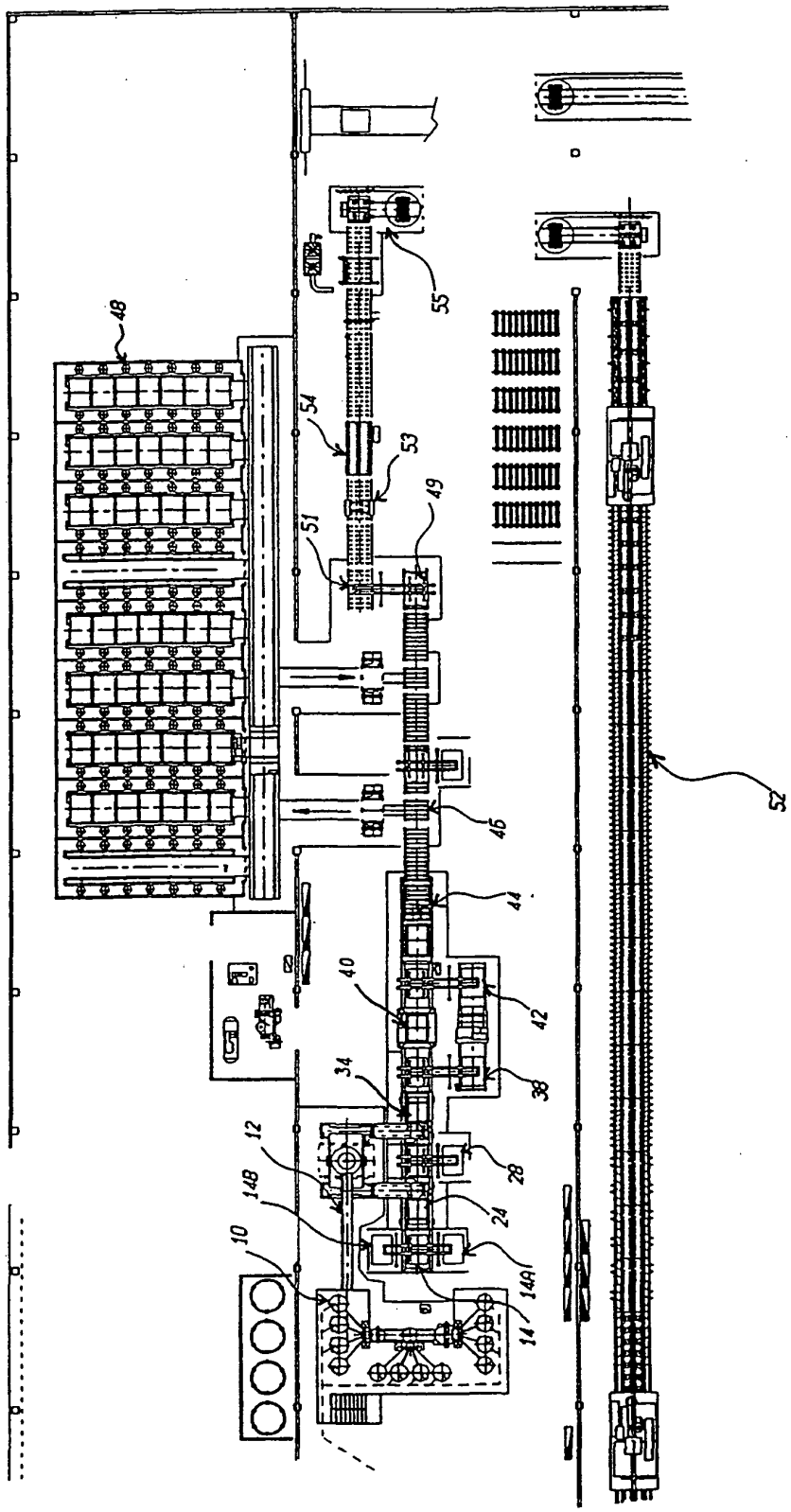
7. Apparatus for manufacturing slabs of ceramic material according to claim 6, characterized in that it further comprises, upstream of the means for supplying said protective layer or sheet of release material and placing it in position, means which supply a reinforcing mesh and place it in position on a starting layer of mixture and downstream of which there are means for supplying and spreading a further quantity of the mixture so as to cover the reinforcing mesh, incorporating it in the mixture before the step for pressing the mixture under vacuum.

8. Apparatus for manufacturing slabs of ceramic material, according to claim 6, characterized in that said protective layer or sheet of fabric is felt.

9. Apparatus for manufacturing slabs of ceramic material, according to claim 8, characterized in that said protective layer or sheet is of material resistant to tensile stress.

10. Apparatus for manufacturing slabs of ceramic material, according to claim 6, characterized in that said permeable release material is paper.

Fig. 1



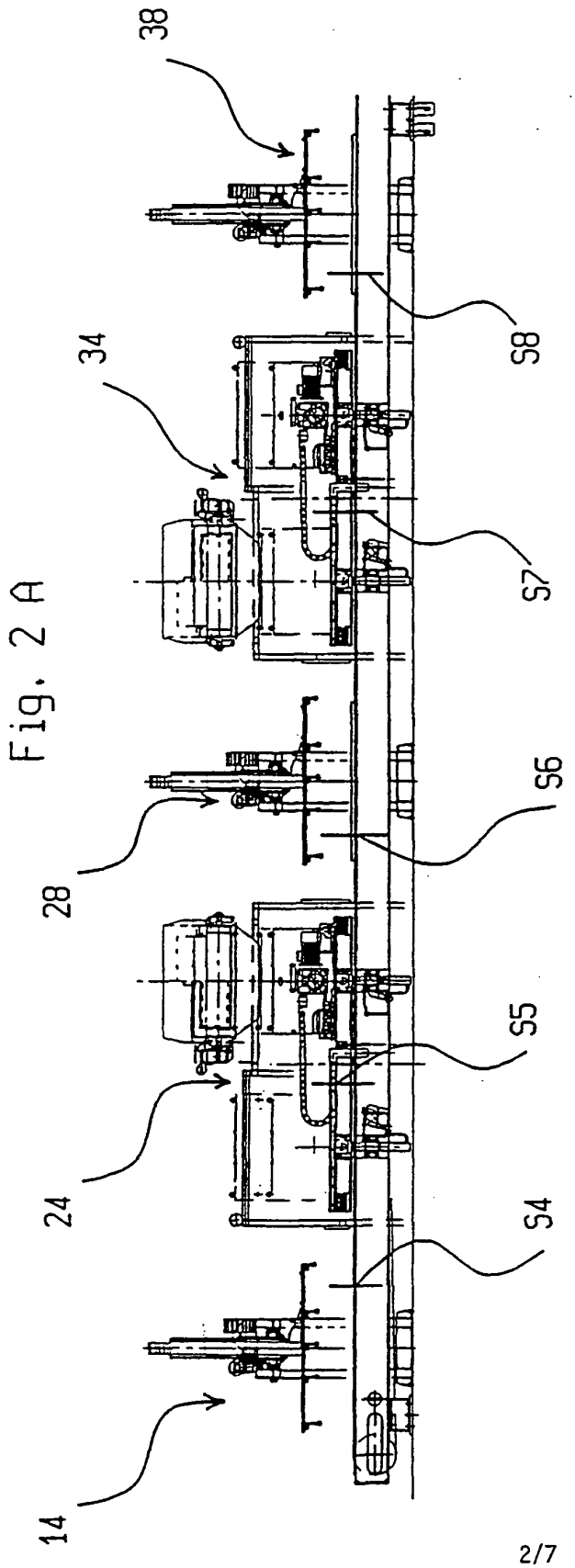


Fig. 2 A

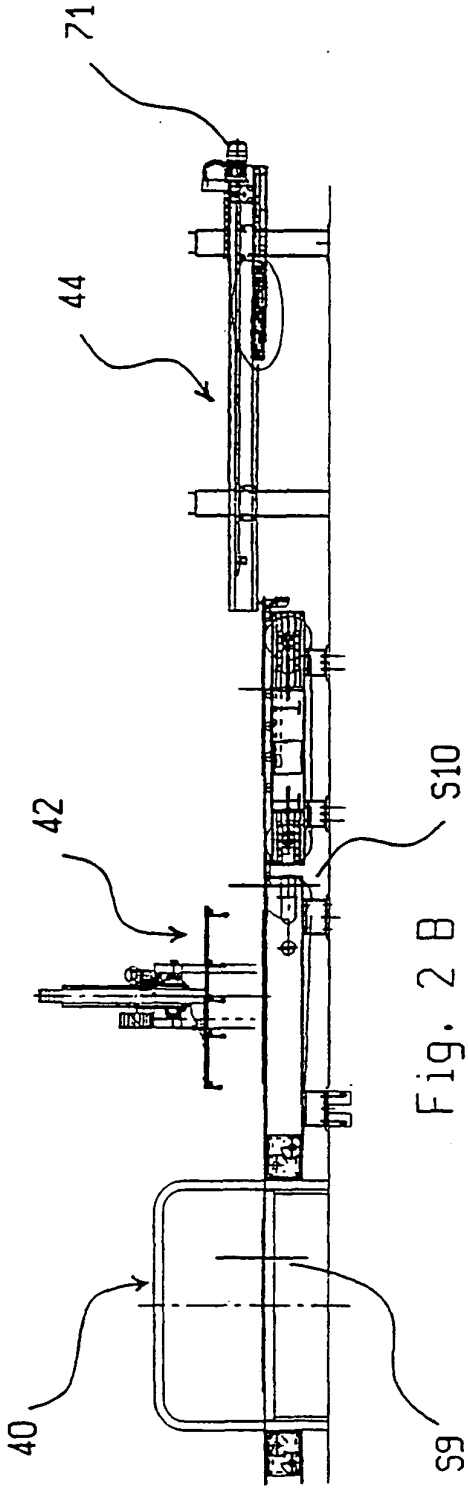


Fig. 2 B

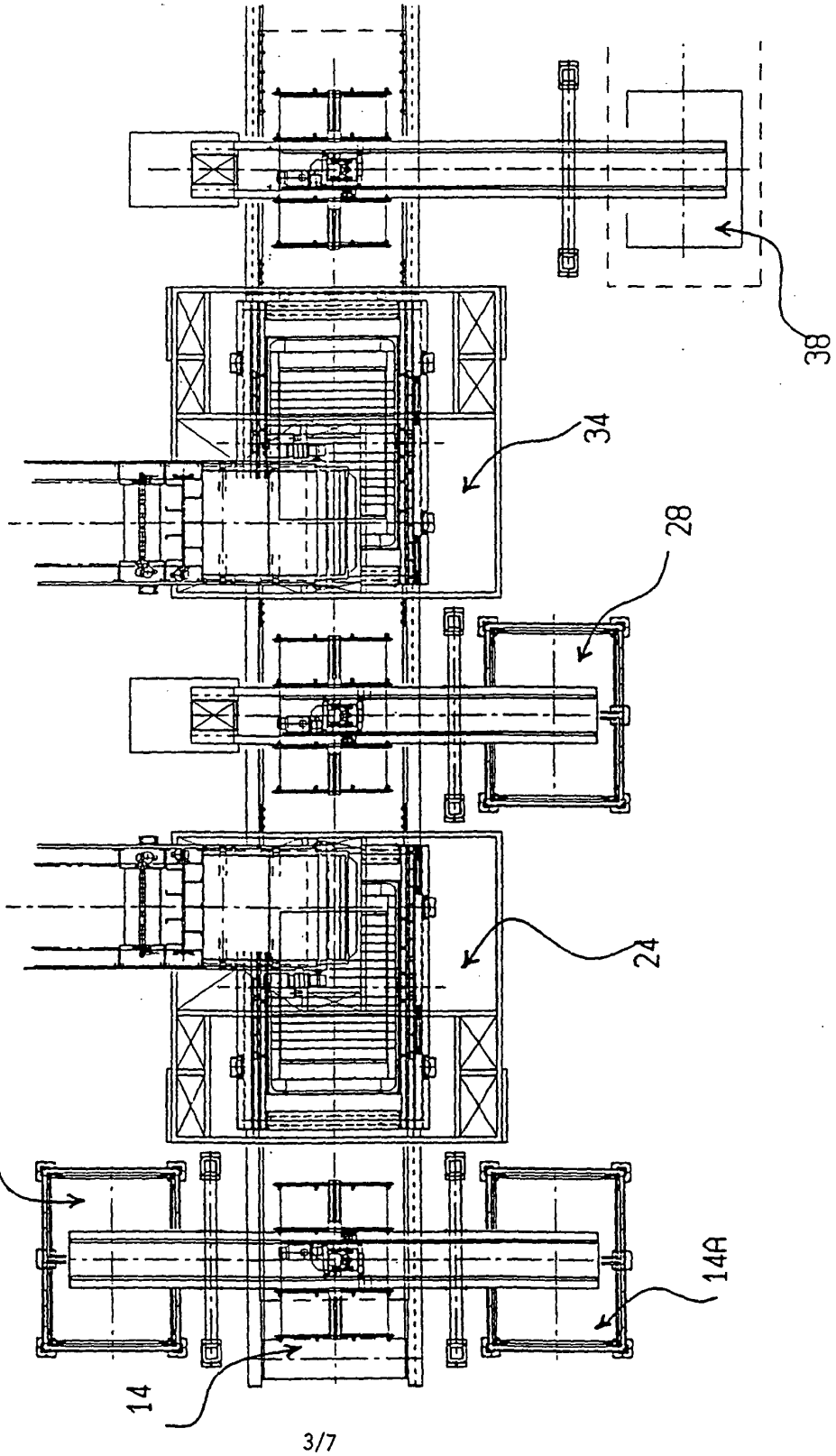


Fig. 3 A

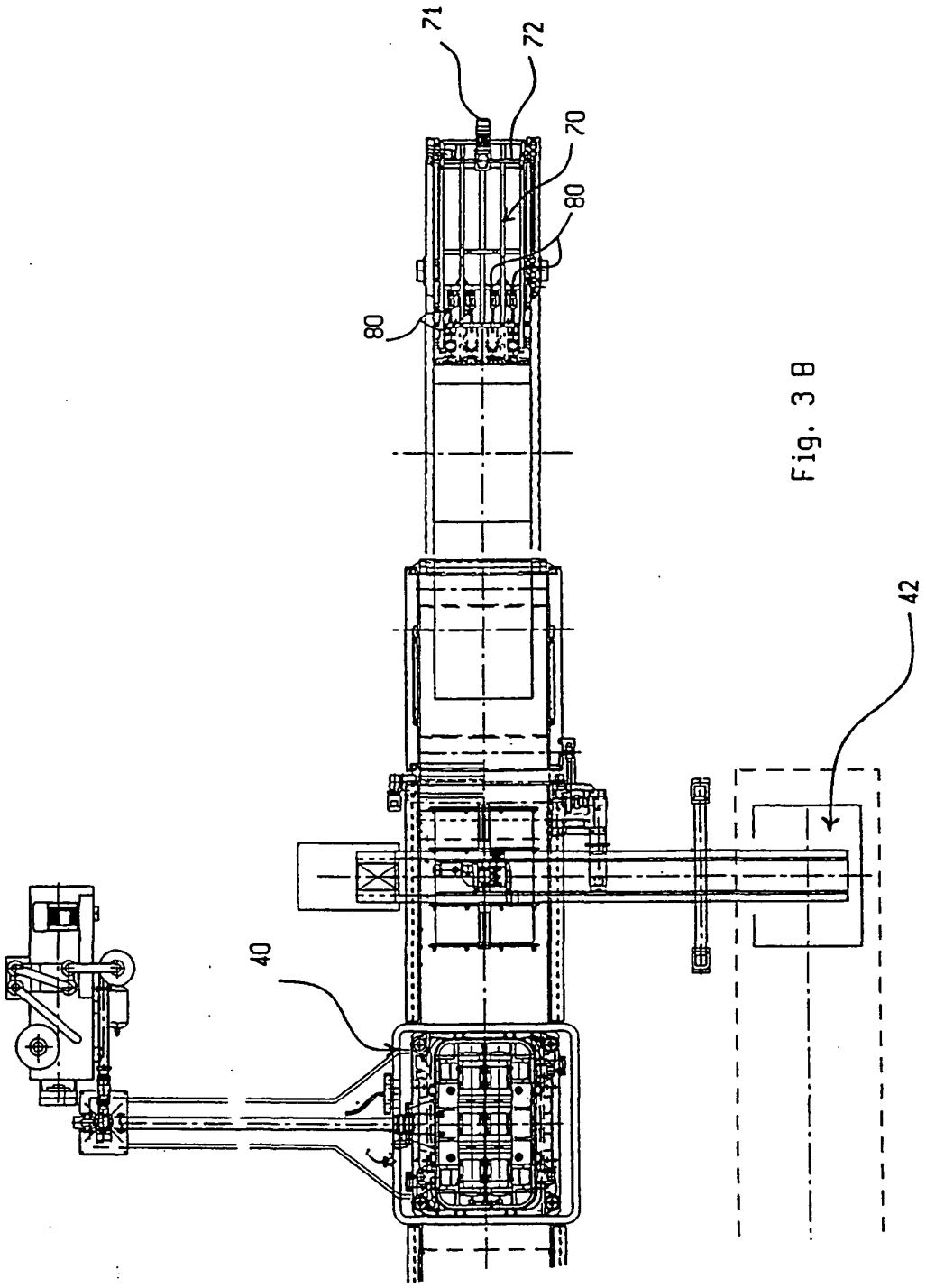


Fig. 3 B

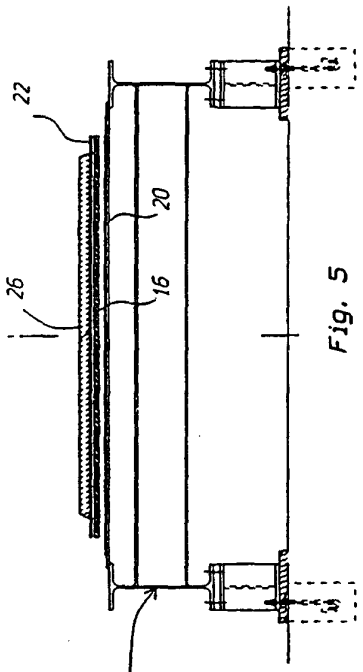


Fig. 5

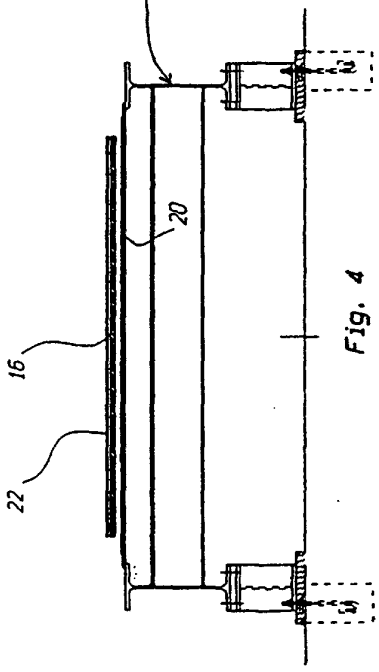


Fig. 4

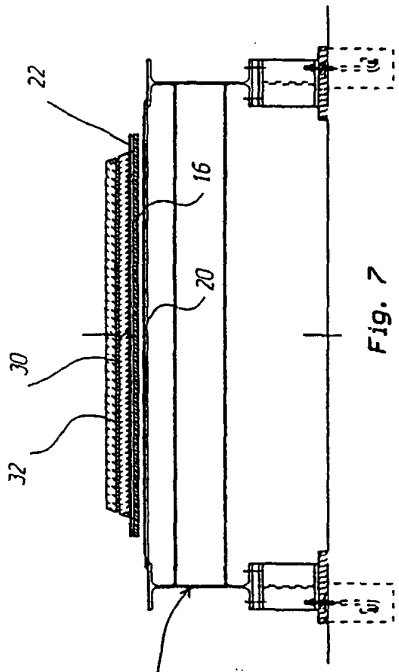


Fig. 7

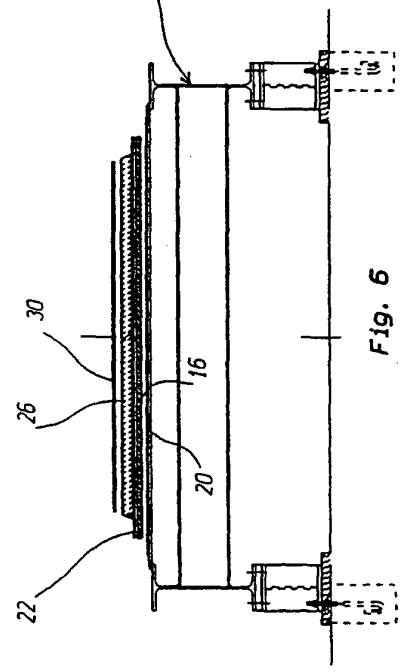


Fig. 6

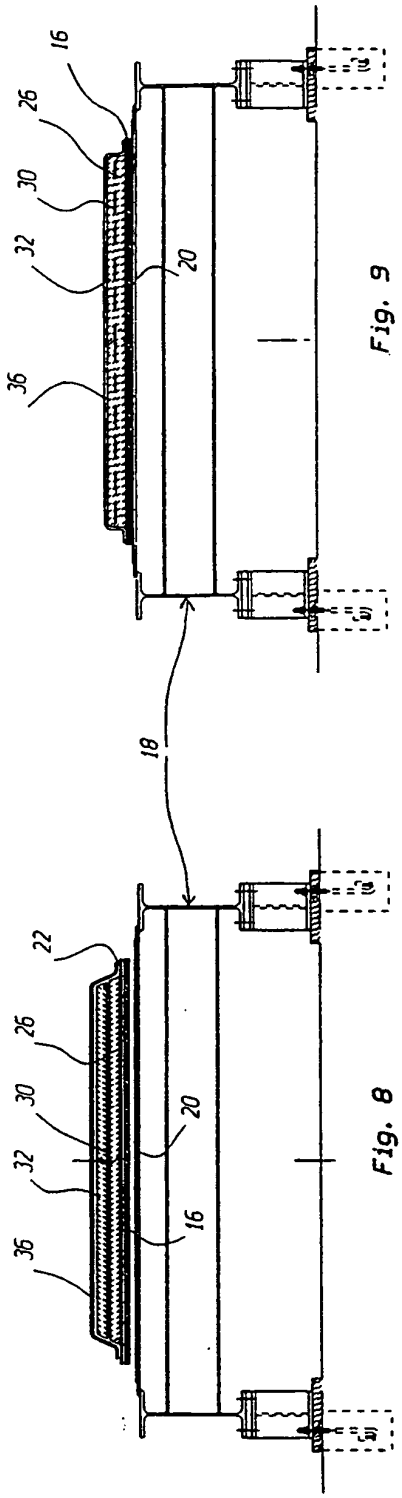


Fig. 9

Fig. 8

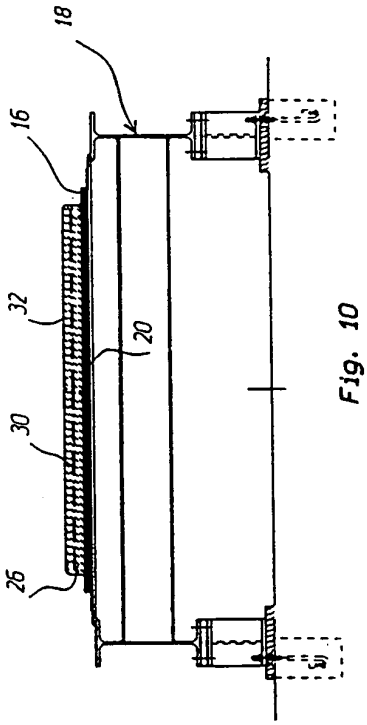


Fig. 10

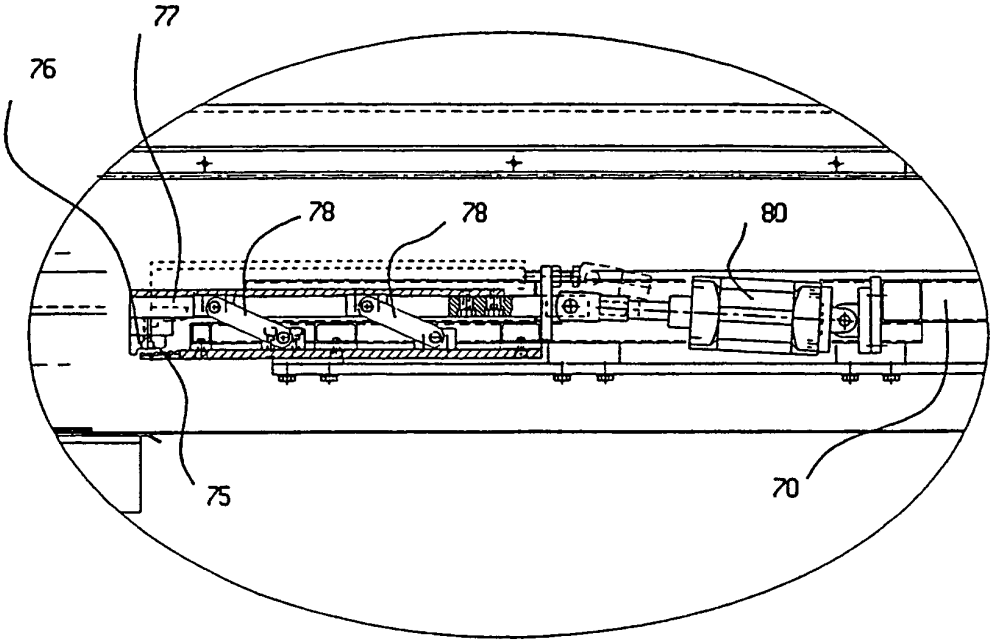


Fig. 11

INTERNATIONAL SEARCH REPORT

International Application No
PCT/EP 98/02258

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 C04B33/00 B28B5/04

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 C04B B28B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 4 908 217 A (COLLEY CHARLES K) 13 March 1990 see column 3, line 6 - line 30; claim 1	1,6
A	DE 44 31 363 A (PROGRAMME 3 PATENT HOLDINGS) 9 March 1995 see column 4 - column 8; examples 1-3	1,6
A	DATABASE WPI Section Ch, Week 9546 Derwent Publications Ltd., London, GB; Class A32, AN 95-354691 XP002075115 & JP 07 241 826 A (REIKO KK) see abstract	1

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[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
20 August 1998	08/09/1998

Name and mailing address of the ISA	Authorized officer
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C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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Information on patent family members

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